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Utility of infrascanner device in the diagnosis of intracranial hemorrhage in patients presenting to the emergency department

Utility of intrascanner device in the diagnosis of intracranial hemorrhage

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Abstract

Aim: In this study, we aimed to compare data from an infrascanner device that can be used at the bedside with infrared technology with data from intracranial computed tomography and to investigate the utility of the new device in patients presenting to the emergency department with head trauma or neurologic symptoms suggesting ICH.

Material and Methods: The measurement was made beginning from the left frontal region of the head and continuing in the right frontal, left temporal, right temporal, left parietal, right parietal, left occipital and right occipital regions. Patient demographics such as age and gender, GCS, time between the incident and evaluation with CT and infrascanner in the emergency department, diagnosis reported by CT and Infrascanner and outcomes were recorded.

Results: A total of 173 patients were included in this study, 73 of them with ICH and 100 were control subjects. The mean GCS score was 11.44±4.03 in the ICH and 14.16±1.07 in the control group with a significant difference between both groups (p<0.01).

When CT scan findings were taken as reference values, the Infrascanner Model 1000 device had a sensitivity of 84.9%, specificity of 30%, positive predictive value of 46.9% and negative predictive value of 73.1% in detecting ICH.

Discussion: The results of this study indicate that the infrascanner model 1000 device significantly records specificity and sensitivity values when used immediately after an incident.

Keywords

Intracranial Hemorrhage, Intracerebral Hemorrhage, Subarachnoid Hemorrhage, Near-Infrared Technology, Infrascanner

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Introduction

Intracranial hemorrhage (ICH) is the most common subtype of stroke (15-20% of all strokes) and a critical disease, usually leading to morbidity and mortality [1, 2]. ICH is the result of extravasation of blood from an artery, capillary or vein. The incidence of ICH is approximately 25 per 100,000 person-years, and ICH mortality is about 40% within 30 days, making this disease one of the most critical acute emergencies [3-5].

Establishing the true diagnosis of ICH in the emergency department is of paramount importance in terms of time management, prevention of complications and survival. Early diagnosis and intervention of ICH is essential for successful treatment in patients presenting with head trauma or neurologic symptoms.

Neuroimaging is essential for the treating clinician to understand the location and volume of hemorrhage, the risk of cerebral injury and to guide emergency treatment. The diagnosis of ICH is usually made on a non-contrasted computer tomography (CT) scan since it is easy to identify blood, which is hyperintense on CT. MRI is also a good option to diagnose ICH and may also be used in the acute phase or later [6, 7] because acute presentation of ICH can be difficult to distinguish from ischemic stroke [8, 9].

However, failure to detect and treat ICH within the first several hours significantly increases the possibility of severe neurologic deficits and even death [10]. Therefore, the time to diagnosis and emergency intervention is critical in ICH, necessitating the development of other imaging/scanning instruments that provide faster results. To address this need, a near-infrared (NIR) system for detection of cerebral hemorrhage was developed and successfully tested at Baylor College by Britton Change and Claudia Robertson [10]. This system, called infrascanner model 1000, was approved by the American Food and Drug Administration (FDA) as an instrument to detect ICH and has been introduced worldwide. Under normal conditions, the brain's absorption can be considered symmetrical. However, when additional underlying extravascular bleed is present, there is a greater local concentration of hemoglobin, which results in significantly greater light absorbance and less reflected component. This difference is detectable by the detectors placed on symmetrical sides of the skull. So far, the infrascanner system has been studied in several countries, including the USA, Canada, Spain, Italy, the Netherlands, Germany, Afghanistan, Russia, Poland, India, China, and Turkey with varying results [10-13].

The objective of this study was to compare data from the infrascanner device that can be used at the bedside with infrared technology with data from intracranial computed tomography and to investigate the utility of this new system in patients presenting to the emergency department with head trauma or neurologic symptoms suggesting ICH.

Material and Methods

Before the beginning, the study protocol was approved by the ethics committee of our hospital. All patients were informed about the objectives of the study and gave written informed consent. The study was conducted in line with the relevant ethical items of the Declaration of Helsinki.

A total of 77 patients who presented to the emergency department of our hospital with head trauma and/or neurologic symptoms suggesting ICH and hematoma detected on CT, and 100 patients who presented with similar complaints, but had no ICH detected on CT as the control group were included in our study. All patients were examined by emergency medicine residents specially trained in the use of the infrascanner device for IVH following CT scans.

All patients were evaluated according to GCS scores determined at the initial neurologic examinations. Based on the medical history and physical exam, including trauma, syncope, headache, and mental fog, patients underwent CT scans and infrascanner examination immediately after CT scans with their informed consent or the consent of their relatives.

In the present study, the Infrascanner model 1000 device and HP mobile information platform were used. The infrascanner model 100 device is equipped with a portable head that has two optic detectors and a diode laser. Measurement data captured from the sensors are transferred to the mobile info platform as wireless and processed at the platform. The measurement was made beginning from the left frontal region of the head and continuing as the right frontal, left temporal, right temporal, left parietal, right parietal, left occipital and right occipital regions (Figure 1).

The frontal region was measured at the level of pupil over the frontal sinus, the temporal region from the anterior ear over the temporal fossa, parietal region from the midpoint of the skull midline and ear level, and the occipital region from the occipital protuberance and mid ear. Portable head of the sensor was cleaned with alcohol after each measurement and the head was changed after each 50 measurements (Figure 2).

Children younger than 4 years, patients with cervical neck injury following trauma, a markedly (so as to prevent measurement by the device) impaired skin integrity at the scalp, cephalic hematoma, expanding so as to cover any of the frontal, parietal, occipital and temporal regions, patients with marked soft tissue infection in the scalp, pregnant women and those who did not give informed consent were excluded from the study.

Patients' demographics such as age and gender, GCS, time between the incident and the evaluation with CT and infrascanner in the emergency department, diagnosis reported by CT and Infrascanner and outcomes were recorded. Regions on the intracranial CT were termed with similar terms to the regions examined with the infrascanner device as the left frontal, right frontal, left temporal, right temporal, left parietal, right parietal, left occipital and right occipital. In addition, hematomas were divided into groups as subarachnoid, intraparenchymal, epidural and subdural.

Statistical Analysis

Statistical analysis of this study was performed using SPSS version 16.0 (SPSS, Statistical Package for Social Sciences, IBM Inc., Armonk, NY, USA). The normality of the data was tested using the Kolmogorov-Smirnov test. Continuous variables were expressed as mean ± standard deviation, minimum, maximum values, while categorical variables were expressed as numbers and percentage. An independent t-test was used in comparison of the continuous variables, while Chi-square test was used to compare the categorical variables. The sensitivity, specificity, positive predictive value and negative predictive value of the Infrascanner device were obtained. p<0.05 values were considered statistically significant.

Results

A total of 173 patients were included in this study, of which 73 had ICH and 100 were control subjects. Of all patients, 103 (5.5%) were male and 70 (40.5%) were female. Among patients with ICH, 47 (64.38%) were male and 26 (35.62%) were female, while among patients in the control group 56 (56%) were female and 44 (44%) were female.

The mean age of the patients was 46.39±26.24 (4-91) years. The mean age was 53.49±25.62 (5-91) in the female and 41.56±25.66 (4-91) years in the male patients. The mean GCS score was found as 11.44±4.03 in the ICH and 14.16±1.07 in the control group with a significant difference between both groups (p<0.01). Demographic and clinical features of the groups are given in Table 1.

In the ICH group, intracerebral hemorrhage was found in 24 (32.88%), subarachnoid bleeding in 17 (23.29%) patients, epidural hemorrhage in 15 (20.55%) patients and subdural hemorrhage in 17 (23.29%) patients. Twelve patients (16.44%) had more than one subtype of ICH.

Regions of hemorrhage detected by infrascanner are shown in Figure 3.

Table 1. Demographic and clinical characteristics of the patients

	ICH	Control	p	t
	mean±SD	mean±SD		
Age	46.01±26.55	46.66±26.14	>0.05	-0.160
GCS	11.44±4.03	14.16±1.07	<0.05	-5.626
Systolic BP	131.92±35.15	135.18±24.51	>0.05	-0.719
Diastolic BP	73.75±17.61	72.81±12.46	>0.05	0.413
Pulse	90.67±18.99	84.73±11.60	0.02	2.369
Time to scanning (min)	44.23±30.15	43.13±33.03	>0.05	0.225

Table 2. Findings of CT scans and infrascanner device

HEMORRHAGE	CT	CT	TOTAL
	YES	NO	
INFRASCANNER YES	62	70	132
INFRASCANNER NO	11	30	41
TOTAL	73	100	173

Table 3. Sensitivity, specificity, positive predictive value and negative predictive value of the Infrascanner device for different regions of the scalp

	FRONTAL	TEMPORAL	PARIETAL	OCCIPITAL
SENSITIVITY	39.00%	63.40%	42.10%	40.00%
SPECIFICITY	62.00%	51.20%	76.20%	65.10%
PPV	17.00%	29.00%	33.30%	9.80%
NPV	83.30%	81.70%	82.40%	91.90%

PPV: positive predictive value; NPV: negative predictive value

Comparison of the findings obtained with CT scan and Infrascanner Model 1000 device is given in Table 2.

When CT scan findings were taken as reference values, Infrascanner Model 1000 device had a sensitivity of 84.9%, specificity of 30%, positive predictive value of 46.9% and negative predictive value of 73.1% in detecting ICH. Sensitivity, specificity, positive predictive value and negative predictive value of the Infrascanner device for different measurement regions of the scalp are given in Table 3.

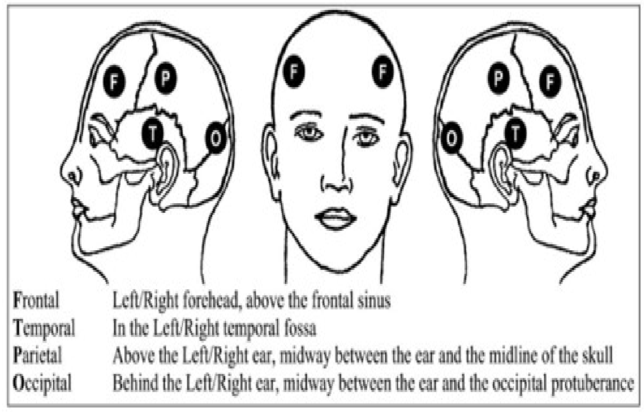

Figure 1. Head regions measured using the Infrascanner device

Figure 2. The Infrascanner Model 1000 is a handheld device that uses near infra-red light to detect intracranial hemorrhage

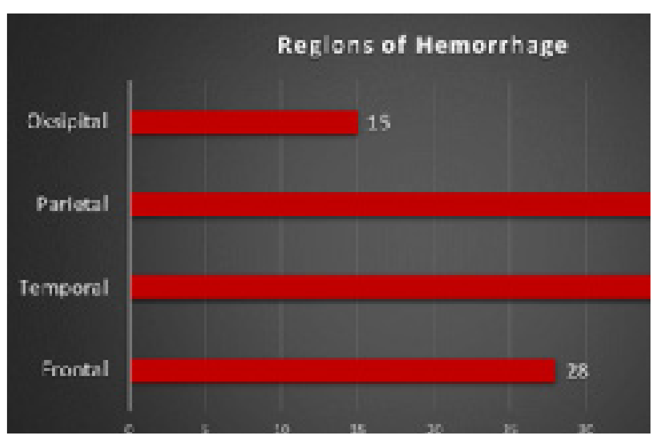

Figure 3. Regions of hemorrhage detected by Infrascanner Model 1000 device

Discussion

Studies have underlined the importance of early identification of causes of brain injury in an effort to prevent secondary brain injury and improve neurological outcomes. Early diagnosis and intervention are critical in ICH for success of treatment and prevention of debilitating and sometimes fatal outcomes. By recognizing hemorrhage at the initial presentation, many treatment options are available for the patients, from medical to surgical treatments. Approximately half of the mortality from ICH occurs within the first 24 hours, highlighting the critical importance of early and effective treatment in the Emergency Department [8].

NIR infrascan technology offers numerous advantages to the bedside clinician. It is a portable painless tool, which can be easily applied to the skull in minutes [14]. This device can perform readings in all eight scalp locations (right and left frontal, temporal, parietal and occipital regions) in 3-5 minutes under ideal conditions [10]. In our study, sensitivity, specificity, NPV and PPV values were found for all measurement locations of the skull.

In our study, the mean age of the patients with ICH was 46.39±26.24 years. In a study by Vermeulen et al. with patients having subarachnoid hemorrhage (SAH), the mean age was reported as 58.1 years. In a study by Xu et al. the mean age was found as 48.3 years in 85 patients [15]. In a study by Cander et al., the mean age was reported as 51.8 years [6]. In another study from China by Liang et al., the mean age of the patients was reported as 41 years [11]. In this context, our finding was in the normal age range.

In the present study, we tested a near-infrared portable bedside tool, Infrascanner Model 1000 for detecting four subtypes of ICH including intracerebral hemorrhage, epidural, subdural hematomas and subarachnoid hemorrhage. According to our results, the NIR intrascanner device detected ICH with a 30% specificity, 84.9% sensitivity, a positive predictive value of 46.9% and negative predictive value of 73.1%.

So far, the near-infrared intrascanner device has been tested in numerous studies worldwide with conflicting results. Liang et al. from China used the portable NIR detector in 305 Chinese patients who underwent CT scan within 12 hours of a blunt or penetrating head injury with a GCS score ≤15 [11]. Cander et al found the mean GCS score as 10.6 [16]. In our study, the mean GCS score was 11.44, similar to that study. It was reported in the study of Liang et al. that NIR infrascanner demonstrated excellent sensitivity (100%) and specificity (93.6%) in detecting traumatic intracranial hematomas. However, patients in our study were not only the ones with traumatic brain injury but also those with neurologic deficit suggesting ICH [11].

Xu et al. used NIR infrascanner to scan intracranial hematomas in 85 patients. As a result, specificity of the device was found as 92.5%, sensitivity as 95.6%, NPV as 94,9% and PPV as 93.5% in detecting ICH [15]. Peters et al. used NIR infrascanner in 25 patients with traumatic brain injury and compared the results with those from CT scans. NIR infrascanner predicted intracranial hematoma with a sensitivity of 93.3% and a specificity of 78.6% [17]. Our study included both patients with head trauma and those with neurologic deficits suggestive of ICH, suggesting that the number of patients may affect the results.

Semenova et al. used the new infrascanner device in the diagnosis of intracranial lesions in children with traumatic brain injuries. The authors concluded that the infrascanner device can be used for detecting intracranial hemorrhages in ambulances and outpatient trauma centers in order to decide hospitalization, CT scans and referral to neurosurgery. They claimed that combined with the other risk factors, infra-scanning may reduce the need for unnecessary CT scans [18]. While the mentioned studies investigated the utility of the intrascanner device in all participants, we used it in all patients who had already undergone a CT scan.

In their pilot study, Salonia et al. applied the infrascanner device on 28 children aged between 0-14 years. The children were divided into two groups with abnormal and normal CT findings. As a result of the study, the authors reported that this new system can be beneficial in the evaluation of a child with possible ICH [19].

Robertson et al. [20] evaluated the utility of infrascanner device in 335 patients and found the specificity as 86.5%, sensitivity as 68.70%, NPV as 84.6% and PPV as 72.5% in the scanned patients. This study confirmed the findings of other studies that NIR technology can be used to screen for the presence of ICH for a simple examination of the difference involved in the hemorrhage and the uninvolved site of the opposite site of the scalp. Differences between the studies seem to be resulted from sample size and type of ICH examined.

Study Limitations

This study has some limitations. It was conducted in a single center with a relatively small number of patients for such a study. Second, sensitivity, specificity, NPV and PPV values could not be examined for all four subtypes of ICH. However, given the conflicting results between the studies, we believe that our findings will contribute to what is known on this topic.

Conclusion

The results of this study indicate that the infrascanner model 1000 device significantly records specificity and sensitivity values when used immediately after the incident. However, the low specificity value that we found shows that although the device provided beneficial information about the patients that should undergo imaging investigations, further studies should be conducted in order to introduce the infrascanner device for scanning or triage purposes in the emergency department.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

None of the authors received any type of financial support that could be considered potential conflict of interest regarding the manuscript or its submission.

References

1. An SJ, Kim TJ, Yoon BW. Epidemiology, risk factors, and clinical features of intracerebral hemorrhage: an update. J Stroke. 2017;19(1):3–10.
2. Hong KS, Bang OY, Kang DW, Yu KH, Bae HJ, Lee JS, et al. Stroke statistics in Korea: part I. Epidemiology and risk factors: a report from the Korean stroke society and clinical research center for stroke. J Stroke. 2013;15(1):2-20.
3. Saad AF, Chaudhari R, Fischbein NJ, Wintermark M. Intracranial Hemorrhage Imaging. Semin Ultrasound CT MR. 2018;39(5):441-56.
4. Portegies ML, Koudstaal PJ, Ikram MA. Cerebrovascular disease. Handb Clin Neurol. 2016;138:239–61.
5. Toyoda K. Epidemiology and registry studies of stroke in Japan. J Stroke. 2013;15(1):21-26.
6. Caceres JA, Goldstein JN. Intracranial hemorrhage. Emerg Med Clin North Am. 2012;30(3):771-94.
7. Shah NA, Wusthoff CJ. Intracranial Hemorrhage in the Neonate. Neonatal Netw. 2016;35(2):67-71.
8. Elliott J, Smith M. The acute management of intracerebral hemorrhage: a clinical review. Anesth Analg. 2010;110(5):1419-27.
9. Feske SK. Ischemic Stroke. Am J Med. 2021;134(12):1457-64.
10. Ayaz H, Izzetoglu M, Izzetoglu K, Onaral B, Ben Dor B. Early diagnosis of traumatic intracranial hematomas. J Biomed Opt. 2019;24(5):1-10.
11. Liang CY, Yang Y, Shen CS, Wang HJ, Liu NM, Wang ZW, et al. Chinese Military Evaluation of a Portable Near-Infrared Detector of Traumatic Intracranial Hematomas. Mil Med. 2018;183(7-8):e318-23.
12. Braun T, Kunz U, Schulz C, Lieber A, Willy C. Nahinfrarotspektroskopie zur Detektion intrakranieller traumatischer Hirnblutungen: Praktikabilitätsstudie in einem Bundeswehrrettungszentrum in Afghanistan [Near-infrared spectroscopy for the detection of traumatic intracranial hemorrhage: Feasibility study in a German army field hospital in Afghanistan]. Unfallchirurg. 2015;118(8):693-700.
13. Bressan S, Daverio M, Martinolli F, Dona' D, Mario F, Steiner IP, et al. The use of handheld near-infrared device (Infrascanner) for detecting intracranial haemorrhages in children with minor head injury. Childs Nerv Syst. 2014;30(3):477–84.
14. Gopinath SP, Robertson CS, Grossman RG, Chance B. Near-infrared spectroscopic localization of intracranial hematomas. J Neurosurg. 1993;79(1):43-47.
15. Xu L, Tao X, Liu W, Li Y, Ma J, Lu T, et al. Portable near-infrared rapid detection of intracranial hemorrhage in Chinese population. J Clin Neurosci. 2017;40:136-46.
16. Cander B, Ertekin B, Dundar ZD, Ascar T, Ertas I, Koyuncu F, et al. Acil Servise Şuur Değişikliği ile Başvuran Hastaların Infrascanner Cihazı ile Değerlendirilmesi (Evaluation of Patients Presenting to the Emergency Department with Changes in Consciousness with Infrascanner Device). Selcuk Med J. 2012;28(2):113-15.
17. Peters J, Van Wageningen B, Hoogerwerf N, Tan E. Near-Infrared Spectroscopy: A Promising Prehospital Tool for Management of Traumatic Brain Injury. Prehosp Disaster Med. 2017;32(4):414-18.
18. Semenova ZhB, Marshintsev AV, Melnikov AV, Meshcheryakov SV, Adayev AR, Lukyanov VI. Infrascanner in the diagnosis of intracranial lesions in children with traumatic brain injuries. Brain Inj. 2016;30(1):18-22.
19. Salonia R, Bell MJ, Kochanek PM, Berger RP. The utility of near infrared spectroscopy in detecting intracranial hemorrhage in children. J Neurotrauma. 2012;29(6):1047-53.
20. Robertson CS, Zager EL, Narayan RK, Handly N, Sharma A, Hanley DF, et al. Clinical evaluation of a portable near-infrared device for detection of traumatic intracranial hematomas. J Neurotrauma. 2010;27(9):1597-604.

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